

*Dedicated to the Preservation of Aerospace Technology*

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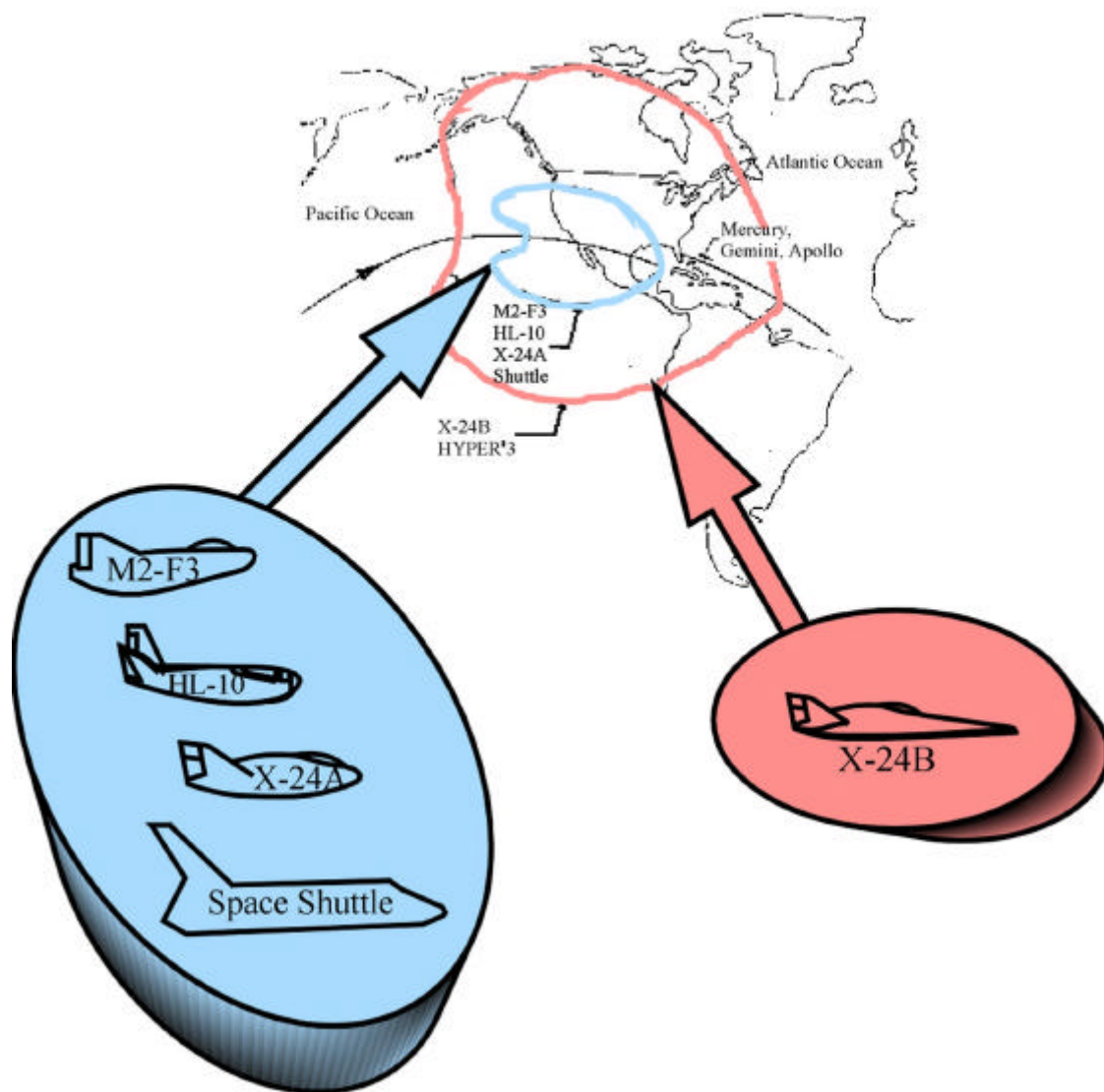
# Testing Lifting Bodies at Edwards

By

**Robert G. Hoey**

A PAT Projects, Inc., Publication

# Air Force/NASA Lifting Body Legacy History Project



**PAT Projects, Inc.**  
**September 1994**

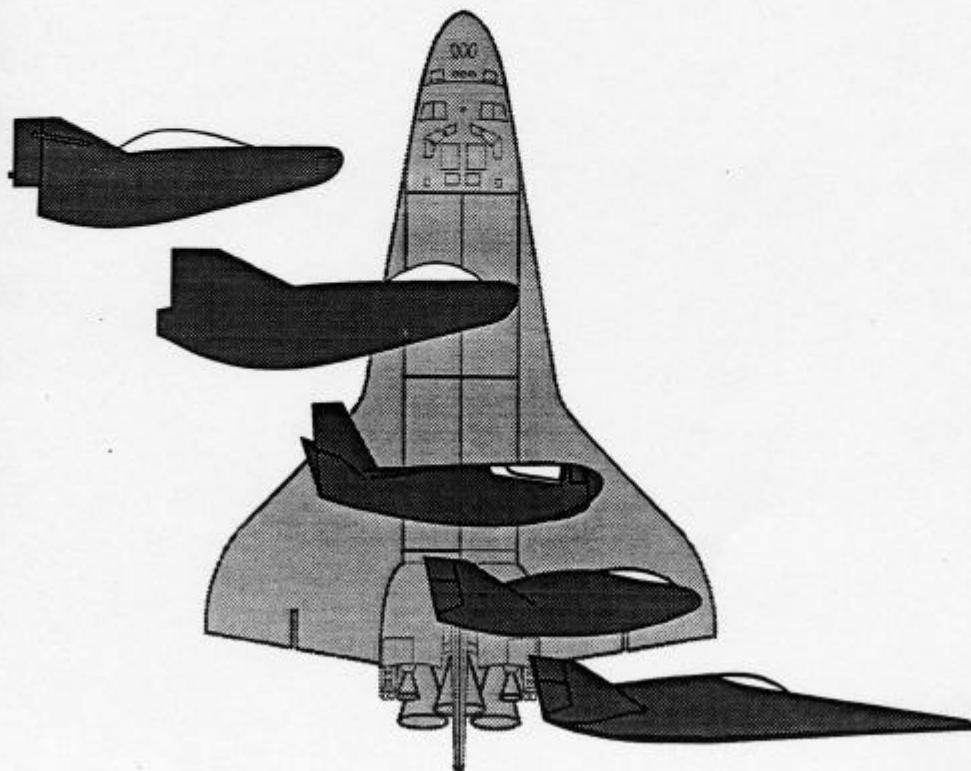
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***LEGACY OF THE LIFTING BODIES***

***VOLUME II***





**M2-F1**

**M2-F2**



**X-24A**

**M2-F3**

**HL-10**



**X-24B**

# PDF Version for Adobe Acrobat®

The conversion of the HTML publication to PDF has been designed to accomodate a hard copy print of this document for single sided page printing layout. the key conversion items are:

1. Elimination of all HTML navigation tools and links.
2. Use of images sized for page layout in lieu of "thumbnails" linked to larger size images.

<b><u>Material</u></b>	<b><u>PDF File</u></b>	<b><u>PDF File Size</u></b>
Contents and Illustrations	coil.pdf	64k
Entire Publication (all of the above files integrated into one)	lbbook.pdf	10,183k
Front Matter (all materials preceding Chapter 1)	fm.pdf	734k
Chapter 1: Returning From Space	ch1.pdf	181k
Chapter 2:Lifting Entry With Horizontal Landing: The Quest Begins	ch2.pdf	312k
Lifting Bodies: A NASA Perspective	nasap.pdf	8k
Chapter 3: The M2-F1 Program	ch3.pdf	637k
Chapter 4: The M2-F2 and M2-F3 Program	ch4.pdf	2,467k
Chapter 5: The HL-10 Program	ch5.pdf	858k
Chapter 6: The X-24A Program	ch6.pdf	1,393k
Chapter 7: The X-24B Program	ch7.pdf	1,168k
Chapter 8: Epilogue	ch8.pdf	336k
Back Matter (all materials following chapter 8)	bm.pdf	2,106k

# **Sponsorship**

## **World Wide Web Publication**



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## **Original Works**

Air Force Flight Test Center  
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21 September 1994

In 1993 the Legacy Resources Management Program provided funding to the Air Force for a study of AF/NASA Lifting Body Program. The Air Force tasked Computer Sciences Corporation (CSC) to undertake a historical, cultural, and technological study of the Lifting Body Program. CSC subcontracted with PAT Projects, Inc., to produce a general and technical narrative history of the Lifting Body Program

# Foreword

At long last the point has been reached where Space Shuttle flights have lost their novelty and become nearly routine matters to the aerospace community. After Columbia's first two-day test mission in April 1981, the initial flush of enthusiasm about the new space era began a steady evolution into a proud but casual acceptance of its technological marvels. Even the Challenger tragedy proved to be only a temporary setback, and now each successful Shuttle mission is seen as a completely normal occurrence. These days an Orbiter falling out of the sky onto a runway at the Kennedy Space Center or Edwards Air Force Base merits little more than a brief segment on the evening news programs.

This is, in the main, a desirable state of affairs. NASA's long-term goal has been to make space activities routine, systematically transforming the adventure and drama of the new space medium into a practical exploitation. Yet this very predictability also minimizes the critical problems involved in each space flight and habituates us to the extraordinary applications of technology which are necessary to overcome them.

Not least of these are the numerous problems involved in returning a Shuttle safely to the ground. Several possibilities were considered during the early design phase of the project. The one ultimately selected--reentering the atmosphere without power and landing--seemed "natural" and unexceptional to the layman, but its simplicity was deceptive. Data from the X-15 studies suggested that a craft with minimal wing area could consistently make successful dead-stick landings. Proving the concept, however, necessitated an elaborate and inherently fascinating effort by AFFTC, NASA and the industry. In the end the two programs--X-15 and Lifting Body--converged to validate the concept which has now been successfully used for the last decade-and-a-half.

Oddly enough, though, the very success of the Lifting Body Program seems to have helped insure its relative obscurity. With the Shuttle Orbiters now in routine operation and no similar space ventures in sight, the lifting body technology has been fully absorbed by the aerospace community but allowed to become dated. At the same time, the Lifting Body Program and its unique aircraft have received singularly little attention from the public, even from the hardy breed of aviation buffs. The muted attention to the subject even extends to the printed page, where very little more than professional papers have seen public print.

In view of this, Robert Hoey has done a commendable service in presenting this long-overdue study of the entire Lifting Body Program. More importantly, although he presents the story from the viewpoint of the engineers and test pilots, he has made it accessible to the layperson who is interested in space activities. Likewise, his associates have explored other program ramifications which are usually neglected in basic engineering studies.

Preserving aerospace technology, and especially the means and processes by which it has been developed, is the central mission of PAT Projects, Inc., which proposed and managed this work. Technology does not exist in a vacuum, and having only the final data of a successful program tells little about how that accomplishment might be replicated. It is apparent that researching the story of the lifting body effort was a singularly worthwhile venture for this group.

Raymond L. Puffer, Ph.D.  
AFFTC History Office  
Edwards Air Force Base

# Introduction

This document attempts to bridge the communication gaps between the technical/scientific community, the history and archival disciplines, and the non-professional aviation enthusiast. It describes the events of the Lifting Body Program with as much objectivity and detail as possible so as to provide an accurate history of the program. At the same time, the technical aspects of the program are discussed in sufficient detail to assure that the engineering community will benefit from the new technology that was derived from these tests. Chapter 1 presents a brief, simplified introduction to the subject of atmospheric entry so that the non-technical reader may also read and understand the lifting body story. Hopefully all readers will sense the excitement, the pioneering spirit, the camaraderie, the "can-do" attitude that prevailed within the small team of engineers and pilots who were privileged to participate in the lifting body flight test program at Edwards.

# Preface

This historical document portrays the Lifting Body Program as seen by the engineers and pilots who actively participated in the development and testing of these unique vehicles. You may notice a lack of reference to political policies and decisions, or media events and labels (for example, International Geophysical Year, Cold War, creation of NASA, Sputnik, Space Race, etc.). Such events or labels are commonly used in historical documents to indicate changes in direction or an altered public perception of advances in technology. In actuality, these events or labels had little, if any, effect in the near term on the Lifting Body Program. They were almost transparent to those actually working in the technical field.

Advancement in science and technology is a continuing process. Advances usually occur through a series of small steps in theory and/or laboratory demonstrations. Often technological "breakthroughs" occur in almost simultaneous, but unrelated demonstrations in different parts of the world. It is occasionally necessary for the scientists to pause in a line of investigation, and allow the engineers to construct a complete operating device to validate their findings and demonstrate practical applications. Periodic demonstration of current technology is important to validate the ability to construct real hardware, and to boost and update the industrial base.

Frequent hardware demonstrations reduce the technical risk for each step. When the cost and complexity of a hardware demonstration becomes very high (such as in most space travel ventures) the decision to build hardware may be deferred for political or economic reasons. This results in fewer demonstrations and therefore higher risks for each step. Engineers then begin looking for low cost, partial demonstrations that will sustain the technological advance but reduce the risk for the next big hardware demonstration step.

The Lifting Body Program falls into the category of a low cost, partial technology demonstration to reduce the high technical risk that was emerging from the Dyna Soar program (discussed in Chapter 2). Notice that the Lifting Body Program was created PRIOR to cancellation of Dyna Soar, and was NOT a result of that cancellation. The ASSET program, discussed in Appendix A, section 4.4, falls into the same category further highlighting the recognition within the technical community of the high technical risk of Dyna Soar. Other similar technology advances and partial demonstrations were continuing in other fields such as the development of new thermal protection materials, power sources and flight control systems. All of these partial technology demonstrations were intended to reduce the risk for whatever larger and more costly demonstration of controlled, manned entry would eventually follow. What follows is the lifting body story told from the perspective of engineers and pilots.

# Acknowledgements

The author wishes to acknowledge the assistance of Johnny Armstrong from the AFFTC Research Projects Office in locating, and making available, various documents and photos that were used in the preparation of this report. Jack Kolf of NASA FRC graciously allowed the use of the heavy-weight Lifting Body Flight Logs which he had assembled earlier from other NASA FRC documents. The Photo Department at NASA FRC were also very helpful in locating and printing copies of various photos which were used in the document. I also appreciate the help of the NASA DFRC Library and AFFTC History Office for personal assistance and access to historical resources.

In a quick-reaction peer review, the draft report benefited from comments of the following individuals who actually participated in the various activities described in this document;

Jack Wesesky	Dyna Soar and X-15
Jack Paulson	HL-10 configuration definition
Clarence Syvertson	M2 configuration definition
A. J. Evans	NASA Headquarters
Fred Stoliker	AFFTC Technical Director
David Richardson	X-24A, X-24B Performance Engineer
Dale Reed	M2-F1, Program Manager
Jack Kolf	X-24B Program Manager for NASA
Johnny Armstrong	X-24A, X-24B Program Manager for AFFTC

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The author also wishes to thank the following members and consultants of PAT Projects, Inc., for their direct contributions to sections of this document, as well as their review of the final manuscript: Betty Love, for gathering photos and preparing the M2-F1 flight log in Appendix C; Bruce Peterson and John Manke for the pilot comments in Appendix B; John McTigue for information about the M2-F2 and HL-10 procurement from Northrop; Lyle Schofield for his assistance in preparing the discussion on aerodynamic heating and low L/D approaches; Anne Millbrooke for her insightful review and her help in reformatting the text for historical validity; Chris Licciardi for computer graphics and production support; and Wayne Ottinger for his overall assistance and management of the effort.

### **World Wide Web (WWW) Publication**

Some minor corrections and additions were made to the original works for the WWW publication. Book Two, The Cold War Context, and most of Book Three, Lifting Bodies As Cultural Resources, were not included in the WWW publication. The author, Robert G. Hoey, and Betty Love provided the minor corrections and additions. With NASA's assistance, the color photographs available were selected as substitutions for the black and white photos original used. Wayne Ottinger, of PAT Projects, Inc., produced the WWW version in both HTML and PDF configurations with the assistance of Carla Thomas (Adobe® Photoshop® 4.0) and Denise Pregonzer (Corel Corporation CorelDRAW™ 7), both under a consulting services order from PAT Projects, Inc. The HTML version was produced with Microsoft® FrontPage 97™ and the PDF version was produced using both Microsoft® Word 97 SR-1 and Adobe® Acrobat 3.0®.

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**For 1280 X 1024 pixel size images from the NASA Dryden photo server, go to: <http://www.dfrc.nasa.gov/gallery/photo/index.html>**

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**X-15s and Lifting Body Research Aircraft in Main NASA Hanger, 1966**

